Outcome of Nasal Valve Obstruction After Functional and Aesthetic-Functional Rhinoplasty

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INTRODUCTION Nasal valve insufficiency is distinct from other anatomic causes of nasal obstruction. Functional rhinoplasty refers to the collective techniques used to reconstruct the lateral nasal wall, typically achieved with the use of spreader and alar grafts. Patients undergoing functional rhinoplasty can also have aesthetic desires and goals achievable with combined aesthetic-functional rhinoplasty.

OBJECTIVE To evaluate the improvement in nasal obstruction symptoms after cartilage graft reconstruction in patients with nasal valve insufficiency and to compare the postoperative improvement between patients undergoing functional and aesthetic-functional rhinoplasty.

DESIGN, SETTING, AND PARTICIPANTS In this prospective multicenter cohort study, 12 participating surgeons enrolled 79 consecutive patients diagnosed as having nasal valve insufficiency as the primary cause of nasal obstruction. Patients underwent functional or aesthetic-functional rhinoplasty. The study collected demographic, clinical, and surgical data from March 2006 to September 2008. Nasal symptoms were evaluated using a validated, disease-specific, quality-of-life instrument. The Nasal Obstruction Symptom Evaluation (NOSE) scale was administered to participants at baseline and 3, 6, and 12 months postoperatively. Follow-up was completed on September 2008, and data were analyzed in September 2009 and in September 2013.

MAIN OUTCOMES AND MEASURES Changes in NOSE scale score (range, 0 to 100, with a higher score indicating greater severity of obstruction) at 3 months between the functional and aesthetic-functional groups.

RESULTS Of the 79 patients, 31 underwent functional and 48 underwent aesthetic-functional rhinoplasty. Overall, an improvement was found in nasal breathing, with a mean decrease of 48.6 points (95% CI, 41.9-55.2; P < .001) at the 3-month assessment compared with the preoperative baseline NOSE scale score (mean [SD], 67.1 [19.7]). The improvement in nasal breathing was similar whether patients underwent functional or aesthetic-functional rhinoplasty (mean [95% CI] NOSE scale score change, 51.4 [42.1-60.7] and 46.6 [37.1-56.1], respectively; P = .49).

CONCLUSIONS AND RELEVANCE Nasal valve reconstruction with spreader and alar grafts is effective in treating patients with nasal valve insufficiency. Combining aesthetic interventions with functional rhinoplasty did not seem to affect the magnitude of improvement in nasal breathing outcome.

LEVEL OF EVIDENCE 2.
Nasal obstruction is a common clinical presentation with an important effect on sleep, exercise, and quality of life. Several methods have been used to evaluate nasal obstruction.\textsuperscript{1,2} Acoustic rhinometry and rhinomanometry provided physical methods to study the nasal airway. Nonetheless, both methods are limited by significant operator variability and unreliable correlation with clinical symptoms.\textsuperscript{3,4} The validation of the Nasal Obstruction Symptom Evaluation (NOSE) scale was an important contribution.\textsuperscript{5,6} The NOSE scale is a disease-specific, quality-of-life instrument with good reliability in assessing severity of symptoms and responsiveness to medical and surgical treatments. The score ranges from 0 to 100, with a higher score indicating greater severity of obstruction.

The anatomy of the nasal airway has received considerable attention in the otolaryngology literature.\textsuperscript{7-9} Mink\textsuperscript{10} was the first to introduce the term nasal valve in 1920; the term vividly describes the narrowest cross-sectional area of the nasal cavity with the greatest resistance to airflow. Experts recognize 2 components of the nasal valve. The external nasal valve is the area in the vestibule formed laterally by the alar rim, medially by the caudal septum and medial crus, and inferiorly by the nasal sill. The internal nasal valve is located further in the nasal cavity (approximately 1.3-1.5 cm from the nares); it is formed laterally by the caudal edge of the upper lateral cartilage, medially by the dorsal septum, and inferiorly by the head of the inferior turbinate. Air accelerates as it enters these narrow segments, creating a decrease in intraluminal pressure. This phenomenon—known as the Bernoulli principle—explains the tendency for dynamic structures of the lateral nasal wall to collapse with inspiration.

The area between the external and internal nasal valves (intervalve area) deserves special attention because it is devoid of cartilage support.\textsuperscript{11} Externally, this area corresponds to the supra-alar crease, and it can be a specific site of collapse in predisposed noses. A recent systematic review and expert consensus statement distinguished nasal valve insufficiency (NVI) from other causes of anatomic nasal obstruction, such as septal deviation or turbinate hypertrophy.\textsuperscript{9} The diagnosis of NVI is based on clinical findings of inspiratory lateral nasal wall collapse and emphasizes the underlying weakness in the corresponding cartilage and soft-tissue structures. Although septoplasty (with or without turbinoplasty) is highly effective in patients with significant septal deviation affecting the nasal valve, the procedure is insufficient for patients with primarily lateral wall weakness. The term functional rhinoplasty refers to a variety of surgical techniques that aim to buttress the lateral nasal wall and prevent its collapse.\textsuperscript{11} A few authors\textsuperscript{12,13} have reported on a variety of methods to address the nasal valve, including the use of stenting implants and flaring sutures. Nonetheless, cartilage reconstruction with spreader and alar-batten grafts continues to be the most widely accepted method with reliable long-term outcome.\textsuperscript{12,13}

Patients with NVI frequently have aesthetic desires. The rhinoplasty surgeon is in a unique position to address both surgical goals in a combined approach. Herein we introduce the term aesthetic-functional to describe rhinoplasty that combines nasal valve reconstruction with aesthetic techniques, such as those used to modify the nasal tip or vault. Demonstrating the effectiveness of functional rhinoplasty has received increasing attention in the literature. Earlier studies\textsuperscript{14-16} reported on subjective and rhinometric improvement with spreader and alar-batten grafts in patients with NVI. Subsequent single-center studies\textsuperscript{19-22} have also demonstrated improvement in patient-reported outcomes using the validated NOSE scale. The primary objective of this study was to evaluate the improvement in nasal obstruction symptoms after cartilage graft reconstruction (spreader and alar grafts) in patients with NVI. We also compared the postoperative improvement between patients undergoing functional reconstruction and those undergoing aesthetic-functional reconstruction.

Methods

Centers

We used the membership directory of the American Academy of Facial Plastic and Reconstructive Surgery to recruit surgeons who routinely performed functional or aesthetic-functional rhinoplasty (≥3 procedures per month). Twelve surgeons agreed to participate in the study (from centers in California, Texas, Illinois, Minnesota, Maryland, New York, and Virginia). The participating centers (Baylor Facial Plastic Surgery Center, Houston, Texas; The Johns Hopkins University, Baltimore, Maryland; Baltimore Center for Facial Plastic Surgery, Baltimore; NYU Langone Medical Center, New York, NY; University of Minnesota, Minneapolis; University of California, San Francisco; University of Virginia, Charlottesville; University of California, Davis, Sacramento; University of Illinois at Chicago; and University of California, San Diego) obtained institutional review board approval through their local institutions, and all participants provided written informed consent during the 1-year recruitment period.

Participants

The surgeon diagnosed NVI based on clinical examination results that demonstrated moderate to substantial findings that included Cottle or modified Cottle maneuver; lateral wall or alar rim collapse; supratip or middle-vault pinching; or narrow internal nasal valve angle (each scored on a defined 4-point scale as minimal, mild, moderate, or substantial). Patients could not have substantial contribution of septal deviation or turbinate hypertrophy (scored on a defined 4-point scale as minimal, mild, moderate, or severe). In addition, patients experienced no improvement with medical or conservative treatment; patients accepted functional or aesthetic-functional rhinoplasty, with the possibility of septoplasty or turbinoplasty as an adjunct intervention to improve their symptoms. Exclusion criteria consisted of (1) a medical condition contributing to nasal obstruction, such as chronic rhinosinusitis, Wegener granulomatosis, sarcoid, craniofacial syndrome, or neoplasm; (2) acute nasal trauma or nasal bone fracture within 3 months; and (3) requirement of concurrent surgery of the head and neck, such as procedures for obstructive sleep apnea and sinus procedures.

Data Collection

We collected demographic, surgical, and clinical data from March 2006 to September 2008. These data included...
Surgical Intervention

All participating surgeons shared a similar approach to nasal valve reconstruction and routinely used spreader and alar grafts. Only patients who were treated with a spreader graft or an alar-batten graft for internal or external NVI were eligible for inclusion in the study. The general surgical methods were standardized but allowed for individual variations by the surgeon that did not divert from the surgical principles of the study. For the spreader graft, external rhinoplasty with suture stabilization or endonasal rhinoplasty with submucosal pocket was acceptable. The spreader graft extended along the dorsal septum, abutting or just inferior to the level of the upper lateral cartilage. The graft was placed along the length of the upper lateral cartilage (typical length, 15-30 mm), but an extended variation under the nasal bone (typical length, >30 mm) was allowed according to the surgeon’s assessment of the defect. For the alar-batten graft, an open rhinoplasty or an endonasal approach was also acceptable to create a precise submucosal pocket. The graft was placed to support the area of maximum collapse or pinching in the lateral nasal wall and extended inferiorly to rest at the level of the pyriform aperture. Variation in the cephalocaudal orientation was allowed according to the following areas requiring support: cephalic to the level of the lower lateral cartilage; at the level of the lower lateral cartilage; or caudal to the level of the lower lateral cartilage. For the spreader and alar graft material, the surgeon had the freedom to use septal, auricular, or rib cartilage. Septoplasty was performed when the septal cartilage was selected as graft material or if the procedure was needed to address a component of the anatomic problem.

The aesthetic-functional group underwent traditional techniques to address the nasal tip or vault, depending on the specific aesthetic goals. Acceptable tip refinement interventions included interdome suture, intradome suture, and lateral crus cephalic trim. Tip repositioning collectively aimed to change the tip projection or rotation using techniques such as tongue and groove, a caudal septum extension graft, or a caudal septum trim. The aesthetic nasal vault interventions were intended to change the dorsum profile or the width of the nasal vault. These interventions included dorsum augmentation (onlay, diced, or crushed cartilage); hump reduction (rasp, osteotome, or cartilage excision), and nasal osteotomies (medial and lateral osteotomies to close an open-roof deformity, correct a deviation or an asymmetry, or change the vault width). Limited nasal tip or vault interventions were used occasionally in the functional group, but these interventions were not performed for aesthetic goals. For example, osteotomies can be performed to correct deviation or to facilitate placement of the spreader graft. Similarly, tip suture techniques or cartilage strut can be performed to restore tip support.

Results

The surgeons identified 98 candidate participants, and of those, 79 patients agreed to participate and were included in the study. Thirty-one patients underwent functional and 48 patients underwent aesthetic-functional rhinoplasty. Only 2 and 6 patients, respectively, were lost to or unavailable for the 3-month follow-up. Figure 1 shows the patient flowchart for the study. The nasal obstruction findings and the nasal valve interventions are summarized in Table 1. The baseline NOSE scale score in this study (mean [SD], 67.1 [19.7]) was consistent with a severe degree of nasal obstruction, which was similar in both groups. An open rhinoplasty approach was used in all patients except 2. The mean length of the spreader and alar grafts was 20 (5) and 18 (3) mm, respectively.
Surgeons used the alar graft method similarly in the functional and aesthetic-functional groups (25 [81%] vs 35 [73%]; P = .43); the use of the spreader graft method was more frequent in the aesthetic-functional group (19 [61%] vs 42 [88%]; P = .007). By criteria definition, the aesthetic-functional group had aesthetic interventions as part of their surgery. These entailed aesthetic tip interventions in 41 patients (85%) and aesthetic vault interventions in 33 patients (69%). In the functional group, limited tip interventions were performed in 5 patients and limited vault interventions in 8 patients, but these interventions were not performed for aesthetic goals. Specific aesthetic interventions performed to the nasal tip included interdome or intradome suture (34 [71%]); lateral crus cephalic trim (24 [50%]); underlay or overlay lateral crus strut (14 [29%]); and tip repositioning to change projection or rotation (26 [54%]). Interventions to the nasal vault included augmentation (16 [33%]), reduction (19 [40%]), and lateral and medial osteotomies (23 [48%]). The functional group had osteotomies performed in 8 patients to facilitate the placement of spreader grafts or to correct deviation. We found a moderate correlation between hump reduction and the use of the spreader graft (Spearman rank correlation, \( \rho = 0.25; P = .03 \)).

Overall, the patients in this study had improvement postoperatively in nasal breathing (Figure 2). The mean improvement in the NOSE scale score was 48.6 points (95% CI, 41.9-55.2; P < .001) at the 3-month assessment compared with the preoperative baseline score. Six patients experienced improvement of no more than 10% from the baseline score (surgical failure), and of those, only 2 (3%) were unsatisfied with the postoperative results. Figure 3 compares the NOSE scale outcome in the functional and aesthetic-functional groups. The functional and aesthetic-functional groups had a similar magni-
The surgical treatment of NVI has received increasing attention among otolaryngologist and rhinoplasty surgeons. Several single-surgeon or single-center studies demonstrated that functional rhinoplasty provides significant improvement in nasal breathing, with or without aesthetic interventions. However, the single-surgeon or single-center design raises concerns about the generalizability (external validity) of the findings. Also, in the absence of a suitable study design to allow direct comparison, whether patients undergoing aesthetic-functional rhinoplasty benefit similarly compared with those undergoing functional rhinoplasty alone remains uncertain. Our results showed improvement in nasal obstruction after surgery. Overall, the mean improvement in the NOSE scale score was 48.6 points at the 3-month assessment compared with the preoperative baseline score. This improvement corresponds to a 65% reduction in baseline score. Rhee et al performed a systematic review evaluating the normative and symptomatic NOSE scale score in patients undergoing surgery. Lipan and Most further provided a severity classification system for nasal obstruction based on the NOSE scale score. Our study showed substantial change from severe obstruction (NOSE scale score range, 55-75) at baseline to normal or mild symptoms postoperatively (NOSE scale score range, 5-25). The magnitude of postoperative improvement was consistent with findings presented by single-center cohorts. In their reports of patients undergoing functional rhinoplasty for nasal obstruction, Rhee et al, Most, and Lindsay found mean improvements in the NOSE scale score of 48.4, 44.6, and 42.7 points, respectively. In their systematic review, Rhee et al similarly showed a mean improvement of 42 points after a variety of surgical procedures to treat nasal obstruction.

Patients undergoing functional rhinoplasty commonly have aesthetic goals and desires. Aesthetic interventions may not contribute favorably to the nasal airflow. A few published studies showed a rhinometric decrease in nasal patency after aesthetic rhinoplasty, although the impact did not seem to be of clinical significance. Furthermore, the aesthetic interventions may compete with the spreader and alar grafts for the available cartilage material. The novel contribution of our study is our ability to compare the functional and aesthetic-functional subgroups in a prospective cohort study. Both groups had similar nasal breathing outcomes (mean [95% CI]

### Discussion

The surgical treatment of NVI has received increasing attention among otolaryngologist and rhinoplasty surgeons. Several single-surgeon or single-center studies demonstrated that functional rhinoplasty provides significant improvement in nasal breathing, with or without aesthetic interventions. However, the single-surgeon or single-center design raises concerns about the generalizability (external validity) of the findings. Also, in the absence of a suitable study design to allow direct comparison, whether patients undergoing aesthetic-functional rhinoplasty benefit similarly compared with those undergoing functional rhinoplasty alone remains uncertain. Our results showed improvement in nasal obstruction after surgery. Overall, the mean improvement in the NOSE scale score was 48.6 points at the 3-month assessment compared with the preoperative baseline score. This improvement corresponds to a 65% reduction in baseline score. Rhee et al performed a systematic review evaluating the normative and symptomatic NOSE scale score in patients undergoing surgery. Lipan and Most further provided a severity classification system for nasal obstruction based on the NOSE scale score. Our study showed substantial change from severe obstruction (NOSE scale score range, 55-75) at baseline to normal or mild symptoms postoperatively (NOSE scale score range, 5-25). The magnitude of postoperative improvement was consistent with findings presented by single-center cohorts. In their reports of patients undergoing functional rhinoplasty for nasal obstruction, Rhee et al, Most, and Lindsay found mean improvements in the NOSE scale score of 48.4, 44.6, and 42.7 points, respectively. In their systematic review, Rhee et al similarly showed a mean improvement of 42 points after a variety of surgical procedures to treat nasal obstruction.

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improvement in the NOSE scale score, 51.4 [42.1-60.7] and 46.6 [37.1-56.1], respectively; \( P = .49 \). This improvement was also supported by the secondary regression analysis, which showed no group effect on NOSE scale outcome (functional vs aesthetic-functional). Thus, adding aesthetic interventions to functional rhinoplasty does not seem to affect the magnitude of improvement in breathing.

The NOSE scale score at the 6- or the 12-month assessment remained stable over time (Figure I). This finding should be interpreted with caution owing to missing data at the longer follow-ups. Nonetheless, the observed stability over time is consistent with previous findings in the literature. In the cohort studied by Rhee et al., the mean additional improvement was 4.9 points, whereas Lindsay reported no significant change with longer follow-up. Few patients in our study did not achieve significant improvement with surgery. We identified 6 patients with no more than a 10% improvement in the NOSE scale score; of those, only 2 patients were not satisfied with their surgery. Analysis among these patients showed no significant correlation with aesthetic interventions or reconstruction methods. We found 2 patterns of surgical failure. In 3 patients, the improvement was poor at 3 months and persisted. Such cases may reflect an inaccurate diagnosis or a failure to address all anatomic components contributing to nasal obstruction. In the other 3 patients, moderate improvement in the NOSE scale score was seen at 3 months, but this improvement was lost during the longer follow-up. This failure may be owing to unfavorable changes over time, such as scarring, contracture, or weakening of cartilage grafts.

Two major methods for nasal valve reconstruction were used in this study: the spreader graft andalar-batten graft. The regression analysis did not show an association between the reconstruction methods and the NOSE scale outcome. Both methods appear to be effective in treating the recognized site of the defect when selected by an experienced surgeon. Nonetheless, our results should not be interpreted as a direct comparison between the effectiveness of spreader and alar grafts. Preoperative andintraoperative assessment may influence the surgeon’s choice of the reconstruction method. Furthermore, spreader and alar grafts can be combined in nasal valve surgery. Some degree of surgeon variability in technique, cartilage material, and choice of reconstruction method was accepted. The analysis of variance results showed no significant difference in NOSE scale outcome between centers \( P = .23 \). This outcome was also supported by the 2-level regression model (patients nested within centers).

Patient preferences and desires are strong factors not only in selecting functional vs aesthetic-functional rhinoplasty but also in considering the type of aesthetic interventions. In such surgical treatments, randomized blinded trials are unrealistic owing to methodologic challenges and ethical concerns. The observational design of this study brings some limitations. Selection bias may contribute to differences in baseline factors. Nonetheless, the clinical characteristics were similar in both patient groups with regard to the baseline NOSE scale score and assessment of nasal obstruction (Table I). Although the alar graft was used similarly, the use of the spreader graft increased in the aesthetic-functional group. This differential increase in spreader graft use is likely related to the performance of hump reduction in the aesthetic-functional group.

Aesthetic interventions were stratified into tip interventions (dome suture, lateral crus cephalic trim, lateral crus strut, and tip repositioning) and vault interventions (hump reduction, dorsum augmentation, and osteotomies). Results of the secondary regression analysis were consistent with those of the primary analysis in that neither tip nor vault aesthetic interventions had a significant effect on the nasal breathing outcome, even when controlled for the methods of reconstruction \( P = .84 \) and \( P = .28 \) for the tip and vault coefficients, respectively. We recognize that isolating the influence of each aesthetic intervention is methodologically and statistically unfeasible. For example, intradome, interdome, cephalic trim, and increased tip projection may all coexist to achieve the desired aesthetic goal. This strong correlation between some aesthetic interventions leads to a confounding effect and troubling colinearity in the statistical analysis. Because the study did not aim to isolate each aesthetic intervention, we evaluated the aesthetic tip and the aesthetic vault interventions each collectively, as often encountered in clinical practice.

The challenge that faces all functional rhinoplasty studies is how to isolate the impact of lateral wall reconstruction (spreader and alar grafts) from that of septoplasty or turbino-plasty. Rhee and Kimbell highlighted this dilemma of a “weak wall vs a narrow straw.” Septal deviation and turbinate hypertrophy can narrow the nasal valve (narrow straw); this fixed anatomic obstruction can overlap with dynamic lateral wall collapse (weak wall), which is the primary defect in patients undergoing functional rhinoplasty. No accepted criterion standard exists to diagnose NVI; clinical assessment by an experienced surgeon remains the most accepted approach. Patients had to meet eligibility criteria of moderate to severe findings on a standardized clinical assessment for nasal valve defects. We specifically reported the findings of a modified Cottle maneuver because it is a widely accepted assessment for NVI (Table I). Although the exact nasal valve defect may not be strictly homogeneous in this study, we aimed to represent the natural variability encountered and treated in routine functional rhinoplasty practice.

Septoplasty is routinely performed as part of rhinoplasty not only to address a potential component of septal deviation but, more importantly, to harvest septal cartilage for graft material. In this cohort, we implemented rigorous eligibility criteria to select patients primarily with lateral wall collapse. The findings in Table I validated this selection by demonstrating a low score on the contribution of septal deviation and turbinate hypertrophy. The subgroup analysis of patients without septoplasty (alternative source of cartilage) showed no difference in the NOSE scale score outcome when compared with those undergoing septoplasty \( P = .18 \). This finding supports previous expert consensus recognizing NVI as a distinct entity, although it may coexist with other anatomic causes. Despite careful patient selection, the overall estimated improvement from functional rhinoplasty may be inflated because septoplasty and turbino-plasty can also improve nasal breathing. However, this possibility is unlikely to have influenced the comparison between the functional and aesthetic-functional groups.
Conclusions

Nasal valve reconstruction with spreader and alar grafts is effective in treating patients with NVI. Overall, an improvement in the NOSE scale score occurred at the 3-month assessment. The magnitude of improvement in nasal breathing was similar in the functional and aesthetic-functional groups. Secondary regression analysis was also consistent even when controlling for differences in the reconstruction methods (spreader and alar grafts). Combining aesthetic interventions with functional rhinoplasty did not seem to alter the magnitude of improvement in nasal breathing outcome.